

INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1939-TRP, A tool to evaluate weather inputs for robust building performance analysis and design

Attached is a Request-for-Proposal (RFP) for a project dealing with a subject in which you, or your institution have expressed interest. Should you decide not to submit a proposal, please circulate it to any colleague who might have interest in this subject.

Sponsoring Committee: TC 4.02, Climatic Information
Co-sponsored by: TC 2.05, Global Climate Change

Budget Range: \$225,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **September 1, 2026**, or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EDT, May 15th, 2026. NO EXCEPTIONS, NO EXTENSIONS. Electronic copies must be sent to rpbids@ashrae.org. Electronic signatures must be scanned and added to the file before submitting. The submission title line should read: **1939-TRP, A tool to evaluate weather inputs for robust building performance analysis and design, and “Bidding Institutions Name” (electronic pdf format, ASHRAE’s server will accept up to 10MB)**

If you have questions concerning the Project, we suggest you contact one of the individuals listed below:

For Technical Matters

Technical Contact
Parag Rastogi
E-Mail: rastogi.parag@gmail.com

For Administrative or Procedural Matters:

Manager Research & Technical Service
Steve Hammerling
ASHRAE, Inc.
180 Technology Parkway, NW
Peachtree Corners, GA 30092
Phone: 404-636-8400
E-Mail: Shammerling@ashrae.org

Contractors intending to submit a proposal must notify the Research Administrator by email no later than May 1, 2026. This notification will ensure that any late or additional information regarding the RFP can be provided prior to the proposal due date. The deadline for submitting technical questions is also Monday, May 1st, 2026.

All proposals must be submitted electronically. Electronic submissions require a PDF file containing the complete proposal preceded by signed copies of the two forms listed below in the order listed below. **ALL electronic proposals are to be sent to rpbids@ashrae.org.**

All other correspondence must be sent to ddaniel@ashrae.org. Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EDT, May 15, 2026.**
NO EXCEPTIONS, NO EXTENSIONS.

The following forms (Application for Grant of Funds and the Additional Information form have been combined) must accompany the proposal:

- (1) ASHRAE Application for Grant of Funds (electronic signature required) and
- (2) Additional Information for Contractors (electronic signature required) ASHRAE Application for Grant of Funds (signed) and

ASHRAE reserves the right to reject any or all bids.

State of the Art (Background)

Weather time series and statistics are an integral part of building and HVAC design and analysis. New methods and sources of weather data include those produced by algorithms and climate models (Belcher, Hacker, and Powell 2005; Rastogi 2016; Gelaro et al. 2017; Grantham, Pudney, and Boland 2018; IPCC 2021; Zeng et al. 2025). Model-generated ‘synthetic’ time series are useful for what-if analyses, robustness checking, and filling in sparse data coverage. At the same time, increasing amounts of weather data are available from non-traditional weather stations such as those on the Weather Underground network. These serve to provide localized weather data at far greater densities than traditional station networks.

There are currently no automated, standard, systematic, and reproducible methods to test the validity of weather time series for use in building and HVAC design and analysis. This applies to any datasets, whether generated using models or measured by non-traditional stations. Scientists who currently curate and generate meteorological and climatological data use heuristics and rules for data cleaning and validation, e.g., the methods described in the documentation for the NASA Power dataset ([NASA POWER | Docs | Methodology](#)). These would form the foundation of the evaluation framework proposed here.

The state-of-the-art in the provision of data for the built environment is to rely on expert knowledge, i.e., experts inspect weather time series manually to determine whether they “look realistic”. This is inevitably slow and error prone, given the increasing availability and access to the new sources of weather data described. This project would build on existing work from meteorological experts (e.g., Lowe et al. 2018; ‘Berkeley Earth’ 2021) and fundamental time series analyses (Duchon and Hale 2011; Shumway and Stoffer 2011; NCEI 2021) to create a tool that is usable by engineers doing HVAC and building energy analyses.

Even the most advanced modern methods to evaluate weather time series are unable to judge whether the source of the data is suitable for the analysis being conducted. Taking an abstract example, while a given time series of dry bulb temperatures from the airport in Atlanta, GA may be a valid representation of dry bulb temperature in abstraction, that does not mean that it is an appropriate representation of the temperature for a building 100 miles (160 km) away. In such a situation, spatial uncertainty or uncertainty due to location-based differences (e.g., impact of urban heat islands) will be mixed with uncertainty due to lack of knowledge about the evolution of the future climate, i.e., temporal uncertainty. Judging the appropriateness of weather data in this case requires specialist knowledge of the location and the impact of spatial and temporal uncertainties, based on a study of the history of that location’s climate. Part of the challenge of this project will be to find whether the rules derived from specialist knowledge can be encoded into a rules-based framework. Previous work by the authors suggests that climate change creates complications where specialist knowledge of a location is no longer enough, and so a framework is increasingly necessary.

There is no existing guidance on how to assess the suitability of novel methods in practice. For example, there have been proposals in the literature to simulate the effects of climate change by using climate data from cities to the south of a given city of interest, e.g., Washington DC for New York City. While this has some intuitive appeal, particularly for communicating the impacts of climate change, there are currently no tools to assess whether this is an appropriate approach. Climate change is not merely a gradual change in the mean temperature of the globe, but rather a complex set of outcomes resulting from an increase in the amount of energy and moisture in the atmosphere. The scope of this project should be limited to assessing parameters considered “within scope” for an ASHRAE-affiliated professional, e.g., the performance of HVAC systems under extreme conditions, overheating in dwellings during heat waves, passive thermal survivability during storm outages, etc.

In evaluating a time series some of the considerations have classically included:

- bias, RMSE, and higher order moments, distribution, period length
- relationships between variables are physically consistent, e.g., dry-bulb v. dewpoint temperatures.

All of these would form the starting point for this project, along with the work carried out so far in different finished and ongoing ASHRAE Research Projects such as:

- 1171-RP “Sources of Uncertainty in the Calculation of Design Weather Conditions in the ASHRAE Handbook of Fundamentals”

- 1477-RP “Development of 3,012 typical year weather files for international locations”
- 1561-RP “Procedure to Adjust Observed Climatic Data for Regional or Mesoscale Climatic Variations”
- 1745-RP “Evaluation of Climate Reanalysis Data for Use in ASHRAE Applications”
- 1771-RP “Energy Modeling of Typical Commercial Buildings in Support of the ASHRAE Building Energy Quotient Rating System”
- 1900-RP “Using simulated weather data with sparse measured data to produce hourly weather files and calculate design conditions”
- 1923-RP “Prepare climatic design conditions for the 2025 ASHRAE Handbook – Fundamentals and ASHRAE Standard 169”

This project will run in parallel to the Handbook of Fundamentals update (WS 1999), at least for some of the time. The two projects are complementary: WS 1999 focusses on the enormously important and complex task of updating and upgrading the Handbook data, which leaves little to no time for novel methods or proposals. As such, TC 4.2 breaks up projects in a given cycle so one has a focussed deliverable – Handbook data (e.g., 1923-RP), while the other tackles an important and consequential research question (e.g., 1900-RP). This WS does not duplicate RP-1900, RP-1923, or WS-1999.

- RP-1900 focuses on generating simulated weather files.
- RP-1923 updates ASHRAE climatic design conditions.
- WS-1999 deals with weather data uncertainty and climate data processing.
- WS-1939 is uniquely concerned with evaluating arbitrary weather time series for validity and suitability, not generating or adjusting weather files.

Justification and Value to ASHRAE

Weather time series have conventionally been treated as deterministic inputs in ASHRAE calculations (e.g., design data). This often leads to an over-reliance on measured data for design and analysis, even if the data being used is severely outdated.

The primacy of ASHRAE and its sister organizations around the world as providers of weather data is being challenged by novel sources, including “citizen science” efforts, and newer approaches such as reanalysis data and climate models. The availability and increasing use of new sources of weather data must be anticipated through a systematic research effort to provide a framework for systematic evaluation. The test suite created by this project may not be fully deterministic in its outcomes, i.e., only some tests will have pass-fail criteria, but allow for comparisons and graded scales of quality. The tests would allow consumers of weather data to make informed decisions before using it for engineering calculations.

While several ASHRAE members are modeling experts and analysts, others are primarily designers and use commercial models and tools. In their workflows, they will almost always select an off-the-shelf weather library. This stems from a lack of confidence in their qualifications to assess a weather file and/or a lack of time. One of the outcomes of this research should be to bolster the quality of existing weather libraries by commercial entities, supporting energy modelers and designers to make more informed choices.

The Chartered Institution of Building Services Engineers (CIBSE) and NASA (<https://power.larc.nasa.gov/>) have agreed to contribute in-kind, providing expertise and data, respectively.

Objectives

Create a set of methods, collectively constituting a decision-making framework, that can be used by an engineer to evaluate the validity, suitability, and appropriateness of a given weather time series for building and HVAC design and analysis. The methods must evaluate both raw time series and statistics describing or characterizing them. The methods must be able to provide scores or thresholds that can be used to decide whether a given time series is a valid representation of a weather parameter and therefore suitable for use in calculations. The methods should cover as many parameters as possible but at least those used in Ch. 14 and Std. 169 to calculate design conditions.

This project will encompass both the development of this framework as well as its implementation in reusable computer code suitable for use in and alongside building performance design and analysis programs. The outputs of

the project may form the basis for an official ASHRAE Guideline as a follow-up. The PMS will evaluate, with the contractor, whether a Guideline, potentially issued jointly with CIBSE, is a useful follow-up.

Scope:

The project is expected to use techniques from time-series analysis and modern but bounded machine-learning methods to create a usable decision framework. Rather than relying solely on ML, the implementation will:

- emphasize statistical tests,
- incorporate physical-consistency constraints,
- assess temporal and spatial coherence, and
- use ML only when benchmarked against deterministic tests.

Early in Phase 1, the contractor will conduct structured user engagement (interviews or surveys) to document how practitioners use weather data and what specific evaluation needs they have. This ensures the final toolkit remains practical and aligned with user expectations.

The framework is expected to deliver an ensemble of methods that together constitute a suite of tests rather than a single pass-fail test. The point of developing a framework, rather than focusing on achieving a single test, is to ensure that the outcomes are generalizable. It should be noted that simply checking against measured data may not be sufficient since measured data often have quality issues, so the creation of a “ground-truth” validation dataset will be an important part of this work. Measured data from high-quality stations will serve as vetted references, while lower-quality or non-institutional stations may be used as challenge cases – not as ground truth. The contractor will be expected to define which problems are being tackled in this project with the project management subcommittee, as creating validation datasets for all possible use cases is likely unfeasible.

The test datasets will come from a selection of stations or grid cells (locations) and sources, like the test climates used for the ComStock project ([ComStock - NREL](#)) or ASHRAE RP-1771. They should be developed in coordination with ongoing projects such as RP-1900 and will form a useful minor output for future case studies and simulation studies. The stations will be selected using criteria proposed by the contractor to ensure good coverage of location types, e.g., coastal, urban, mountain, etc. The test data must be obtained from the following types of datasets:

1. Reanalysis data: MERRA2 and ERA5 datasets
2. Downscaled GCM data: using any method for downscaling
3. Data from hobby or non-institutional weather stations
4. Data from hyperlocal forecast and interpolated data providers

It is expected that the framework would connect to the BESTEST suite of tests for building simulation programs. The framework will be implemented in modern interpreted languages such as Python and R (other languages proposed by the contractor will be considered by the PES), ready to be integrated with major energy analysis tools such as EnergyPlus and TRNSYS. The contractor is encouraged to communicate with potential users and integrators during Phase 1 below to ensure wider dissemination and adoption.

As part of the exploration of appropriateness, this project can provide additional benefits by building on, and helping to update, the assumptions underlying the data published in Chapter 14 / Std. 169. For example, (Hubbard et al. 2005) suggested that temperature design conditions accurate to within 1°C is good enough. They also suggested a minimum period of record of 8 years. This work will evaluate if these are still valid assertions.

It is expected that ground measurements from weather stations will play a significant role as follows:

1. high-quality, manually-vetted time series can be used as examples of “ground truth” in the development of the framework, and
2. lower-quality time series from non-conventional stations can be used as candidates for evaluation by the same framework.

Similarly, the contractor will be asked to demonstrate the impact of the recommendations of the test suite on sample buildings to demonstrate the utility and impact of using / not-using this test suite for building design and analysis.

ADVANCEMENTS FORESEEN

This project advances the state of the art by developing the first open, reproducible evaluation framework – implementable in modern software – specifically tailored to building performance analysis. While many climate data providers implement their own QC procedures, none provide a comprehensive, ASHRAE-oriented approach to evaluate:

- meteorological validity
- physical consistency
- spatial/temporal coherence
- appropriateness for building-sector use cases

The framework will integrate:

- Statistical distribution tests and moment comparisons
- Physical-consistency checks (e.g., dewpoint \leq dry-bulb)
- Temporal and spatial coherence checks
- Optional, bounded ML-based anomaly detection, strictly benchmarked against deterministic tests

Since no open, purpose-built evaluation framework exists for evaluating weather data, this project would advance the state of the art by creating an automated, standard, systematic, and reproducible suite of tests that can be implemented in building performance evaluation workflows. The outcomes would advance the cause of better input data for building and HVAC simulation and design. Since the proposed test suite would allow a user to determine the suitability of weather time series for a given project, it would result in analyses that are better informed about the impact of a crucial boundary condition – the climate.

It is expected to be very difficult to create a deterministic set of binary (go/no-go) rules or methods to address validity and appropriateness exactly. However, a set of tests of varying strictness implemented in a toolbox would give engineers and analysts enough confidence to judge the relevance of data to application. The goal is not to come up with a single rule, but rather to systematize the evaluation procedure.

BENCHMARKING METHODOLOGY

To ensure that the evaluation framework is scientifically defensible and practically useful, the contractor will validate the methods using a structured set of benchmark tests. These include:

- 1) Synthetic anomaly datasets
 - a) Time series with intentionally injected errors (e.g., step changes, stuck sensors, unrealistic humidity)
 - b) Allows controlled testing of detection performance
- 2) High-quality stations used as “ground truth”. These act as reference-quality datasets for statistical comparisons.
 - a) NOAA ISD
 - b) NOAA GHCNd
 - c) Manually vetted stations when necessary
- 3) Spatial-coherence checks
 - a) Comparing nearby stations or grid cells
 - b) Testing whether spatial correlations behave realistically
- 4) Sensitivity tests in building simulations
 - a) Running sample building models with:
 - i) vetted datasets
 - ii) degraded datasets
 - iii) non-institutional datasets
 - b) Demonstrating how errors in weather inputs propagate through load calculations, comfort assessments, and equipment sizing

MINIMUM SUCCESSFUL OUTCOMES

- 1) A documented evaluation framework
 - a) Describing statistical tests, physical constraints, and coherence metrics
 - b) Sufficient detail to allow independent implementation by third parties
- 2) A reproducible benchmarking suite
 - a) Datasets, expected results, and interpretation instructions
- 3) A software implementation
 - a) Delivered in Python (preferred) or R
 - b) Includes documentation, example workflows, and automated tests
- 4) Demonstrated integration
 - a) At least one successfully tested integration pathway with a building simulation or design tool
- 5) PMS approval of all methodological components
 - a) All tests must be reviewed and accepted as scientifically justified and practically applicable

PHASING

Phase 1: Active Development (18 months)

During this phase, the contractor will actively develop the methods. The final report produced at the end of this phase will describe the methods in sufficient details as to be independently reproducible in computer code. The contractor will also host the original code implementing these methods in a public code repository with versioning (version control). Finally, the PES will examine the results of pre-agreed tests.

Task 1.0 - Problem Definition & User Needs (M0-M6)

The contractor will conduct structured interviews and/or surveys with practitioners to understand:

- how weather data is currently selected and used
- what problems occur most frequently
- what capabilities the evaluation framework must include

Task 1.1 - Implementation Framework (M0-M2)

The contractor will define:

- programming language (Python preferred, R acceptable)
- repository structure and code architecture
- version control and automated testing setup

Task 1.2 - Test Datasets (M2-M4)

The contractor will curate representative datasets drawn from:

- reanalysis products (MERRA2, ERA5)
- high-quality measurement sites (NOAA GHCNd)
- downscaled GCM projections

Task 1.3 – Methods (M

The contractor will prototype methods covering:

- statistical distribution tests
- physical-consistency checks
- time-series and correlation structure tests
- spatial and temporal coherence checks
- optional ML-based anomaly detection (must be benchmarked)

Phase 2: Dissemination and Maintenance: User Interaction and Integration (12 months)

In this phase, the contractor will reach out to potential users and integrators, e.g., EnergyPlus, NASA POWER, IES, DesignBuilder, TRNSYS, etc. for feedback on the usability of the toolkit. The contractor and PES will determine the viability, scope, and desirability of responding to requested enhancements and other feedback from user reports. If the PES agrees that certain requests are reasonable and desirable, the contractor is responsible for implementing

them in a timely manner. The contractor will make reports to the PES on interactions with integrators. The cost of methodological problems or bugs in implementation reported by potential integrators will be borne by the contractor.

Task 2.1 - Integration with Performance Simulation and Design Tools

The contractor will engage with selected tool providers such as:

- EnergyPlus
- TRNSYS
- IES
- DesignBuilder
- NASA POWER (data delivery platforms)

Task 2.2 - User Feedback and Enhancements

The contractor will:

- Document all user and integrator feedback received after deployment of the testbed
- Maintain a log of bugs, feature requests, and enhancement suggestions
- Implement agreed-upon enhancements (subject to PES approval)
- Provide monthly reports summarizing progress on fixes, refinements, and user engagement outcomes

Deliverables:

Technical Deliverables

The technical deliverables mentioned below are split into three categories as follows:

- i. Internal reports delivered to the Project Evaluation Subcommittee and relevant stakeholders.
- ii. External publications and presentations in suitable conferences and journals
- iii. Computer code made available through a git repository hosted with a suitable web-based provider

Phase 1 – Active Development (Month 0-18)

Task 1.0: Problem Definition

- a. Interim reports (Quarterly starting from month 3) on methods available in literature, user needs report (voice of customer), and statement of proposed framework requirements.
- b. Interim report and PMS check-in (Month 3 and 6) on feedback from potential users and integrators.

Task 1.1: Implementation framework

- c. Interim report and PMS check-in (Month 2) on the choice of language, implementation framework and architecture, and maintenance proposal.
- d. Final deliverable (Month 18): A toolkit implementing these methods, delivered in a modern interpreted programming language such as (in order of preference):
 - Python
 - R
 - Other languages can be proposed by the contractor and will be considered by the PES.

Task 1.2: Test Datasets

- e. Interim report and PMS check-in (Month 6) on the test datasets and case studies under consideration, along with descriptive statistics and selection criteria.
- f. Final report (Month 18) on the use of these test datasets with the methods developed.
- g. Test dataset (Month 12) of weather data collected for validating and testing the methods.

Task 1.3: Methods

- h. Interim report (7, 8, 9 months) describing the methods being considered, along with the challenges and successes with test datasets.
- i. Test bed (12 months) made available to PES and selected stakeholders for active testing.

- j. Final report (18 months) documenting the full details of the methods developed in this project. The methods should be described in sufficient mathematical detail as to be independently implementable in code by a third party.

Phase 2 – Dissemination and Maintenance: User Interaction and Integration (Month 18-30)

Task 2.1: Integration with performance simulation and design tools

- k. Report and PMS check-in (Month 19) on tools selected and approach.
- l. Report and PMS check-in (Month 21) on framework for integration
- m. Final deliverable (Month 30): tested modules or programs suitable for use within or alongside selected performance simulation and design tools

Task 2.2: User feedback

- n. Report (Monthly) on bugs, feature requests, and enhancements requested
- o. Report (Monthly) on bug fixes and enhancements implemented.

Progress, Financial and Final Reports, Research Paper(s), and Data shall constitute the only deliverables (“Deliverables”) under this Agreement and shall be provided as follows:

a. Progress and Financial Reports

Progress and Financial Reports, in a form approved by the Society, shall be made to the Society through its Manager of Research and Technical Services at quarterly intervals; specifically, on or before each January 1, April 1, June 10, and October 1 of the contract period.

Furthermore, the Institution’s Principal Investigator, subject to the Society’s approval, shall, during the period of performance and after the Final Report has been submitted, report in person to the sponsoring Technical Committee/Task Group/Multidisciplinary Task Group (TC/TG/MTG) at the annual and winter meetings, and be available to answer such questions regarding the research as may arise.

b. Final Report

A written report, design guide, or manual, (collectively, “Final Report”), in a form approved by the Society, shall be prepared by the Institution and submitted to the Society’s Manager of Research and Technical Services by the end of the Agreement term, containing complete details of all research carried out under this Agreement. Unless otherwise specified, electronic copies of the final report shall be furnished for review by the Society’s Project Monitoring Subcommittee (PMS).

Following approval by the PMS and the TC/TG/MTG, in their sole discretion, final copies of the Final Report will be furnished by the Institution as follows:

- An executive summary in a form suitable for wide distribution to the industry and to the public.
- Two copies ; one in PDF format and one in Microsoft Word.

c. Research Paper(s)

One or more papers shall be submitted first to the ASHRAE Manager of Research and Technical Services (MORTS) and then to the “ASHRAE Manuscript Central” website-based manuscript review system in a form and containing such information as designated by the Society suitable for publication. Papers specified as deliverables should be submitted for publication in the Science and Technology for the Built Environment (STBE). The paper(s) shall conform to the instructions posted in “Manuscript Central” for Science and Technology for the Built Environment papers. The paper title shall contain the research project number at the

end of the title in parentheses, e.g., (1939-RP). ASHRAE Conference papers are **not** acceptable as deliverables from ASHRAE research projects unless explicitly approved by a vote of the PMS and TC and communicated to MORTS. Conference paper(s) shall conform to the instructions posted in “Manuscript Central” for ASHRAE Conference papers and the title shall contain the research project number at the end of the title in parentheses, e.g., 1939-RP).

All papers or articles prepared in connection with an ASHRAE research project, which are being submitted for inclusion in any ASHRAE publication, shall be submitted through the Manager of Research and Technical Services first and not to the publication's editor or Program Committee.

d. Data

Data is defined in General Condition VI, “DATA”.

e. Project Synopsis

A written synopsis totaling approximately 100 words in length and written for a broad technical audience, which documents 1. Main findings of research project, 2. Why findings are significant, and 3. How the findings benefit ASHRAE membership and/or society in general shall be submitted to the Manager of Research and Technical Services by the end of the Agreement term for publication in ASHRAE Insights.

The Society may request the Institution submit a technical article suitable for publication in the Society’s ASHRAE JOURNAL. This is considered a voluntary submission and not a Deliverable. Technical articles shall be prepared using dual units; e.g., rational inch-pound with equivalent SI units shown parenthetically. SI usage shall be in accordance with IEEE/ASTM Standard SI-10.

Level of Effort

The project is planned to have 30-month duration in 2 phases (spread over 5 society meetings) with a budget of \$225,000. The spending should be split between the two phases approximately as follows:

1. Phase 1 – 70%
2. Phase 2 – 30%

Budget & Effort Alignment

- Total Budget: \$225,000
- Total Effort: 32 Person-Months
- Phase 1 (Months 0–18): 22 PM (~70%)
- Phase 2 (Months 18–30): 10 PM (~30%)

Other Information for Bidders

The Chartered Institution of Building Services Engineers (CIBSE) and NASA have agreed to contribute in-kind, providing expertise and data as required. NASA has agreed to provide weather / climatic data. CIBSE will join in the review meetings as invited.

Proposal Evaluation Criteria

No.	Proposal Review Criterion	Weighting Factor
1	Contractor’s understanding of Work Statement as revealed in proposal	15%
2	Quality of methodology proposed for conducting research	25%
3	Contractor’s capability in terms of facilities and relevant prior research	20%
4	Qualifications of personnel for this project	15%
5	Probability of meeting the objectives and schedule of the Work Statement	25%

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1	Implementation framework, and data set and methods selection	9
2	Test bed available for active testing	12
3	Phase 1 complete	18
4	Integration framework report	21
5	Phase 2 complete	30

References

1. ASHRAE. 2021. 'ASHRAE Research Strategic Plan'. Atlanta, GA, USA: ASHRAE. <https://www.ashrae.org/file%20library/technical%20resources/research/research%20strategic%20plan/research-strategic-plan.pdf>.
2. Belcher, S. E., J. N. Hacker, and D. S. Powell. 2005. 'Constructing Design Weather Data for Future Climates'. *Building Services Engineering Research and Technology* 26 (1): 49–61. <https://doi.org/10.1191/0143624405bt112oa>.
3. 'Berkeley Earth'. 2021. 2021. <http://berkeleyearth.org/>.
4. Duchon, Claude, and Robert Hale. 2011. *Time Series Analysis in Meteorology and Climatology: An Introduction*. Wiley.
5. Gelaro, Ronald, Will McCarty, Max J. Suárez, Ricardo Todling, Andrea Molod, Lawrence Takacs, Cynthia A. Randles, et al. 2017. 'The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)'. *Journal of Climate* 30 (14): 5419–54. <https://doi.org/10.1175/JCLI-D-16-0758.1>.
6. Grantham, A. P., P. J. Pudney, and J. W. Boland. 2018. 'Generating Synthetic Sequences of Global Horizontal Irradiation'. *Solar Energy* 162 (March):500–509. <https://doi.org/10.1016/j.solener.2018.01.044>.
7. Huang, Y. Joe. 2012. 'International Weather for Energy Calculations'. ASHRAE Research Project RP-1477. Development of 3012 Typical Year Weather Files for International Locations. Atlanta, GA, USA: ASHRAE. <https://www.ashrae.org/resources--publications/bookstore/international-weather-for-energy-calculations>.
8. Hubbard, Kenneth G, Kenneth E Kunkel, Kelly T Redmond, and Arthur T Degaetano. 2005. 'Sources of Uncertainty in the Calculation of Design Weather Conditions'. In , 111:317–26.
9. IPCC. 2021. 'Climate Change 2021 - The Physical Science Basis'. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland: Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf.
10. Lowe, Jason A, Dan Bernie, Philip Bett, Lucy Bricheno, Simon Brown, Daley Calvert, Robin Clark, et al. 2018. 'UKCP18 Science Overview Report'. *Met Office Hadley Centre: Exeter, UK*.
11. NCEI. 2021. 'Global Historical Climatology Network Daily (GHCND)'. National Centers for Environmental Information (NCEI). 2021. <http://www.ncei.noaa.gov/products/land-based-station/global-historical-climatology-network-daily>.
12. Rastogi, Parag. 2016. 'On the Sensitivity of Buildings to Climate: The Interaction of Weather and Building Envelopes in Determining Future Building Energy Consumption'. PhD, Lausanne, Switzerland: Ecole polytechnique fédérale de Lausanne. EPFL Infoscience. <https://doi.org/10.5075/epfl-thesis-6881>.
13. Shumway, Robert H, and David S Stoffer. 2011. *Time Series Analysis and Its Applications: With R Examples*. New York, NY: Springer.
14. Wilcox, S, and W Marion. 2008. 'Users' Manual for TMY3 Data Sets'. National Renewable Energy Laboratory. <http://www.nrel.gov/docs/fy08osti/43156.pdf>.
15. Zeng, Zhaoyun, Ji-Hyun (Jeannie) Kim, Haochen Tan, Yuqing Hu, Parag Cameron-Rastogi, Daniel Villa, Joshua New, Jiali Wang, and Ralph T. Muehleisen. 2025. 'A Review of Future Weather Data for Assessing Climate Change Impacts on Buildings and Energy Systems'. *Renewable and Sustainable Energy Reviews* 212 (April):115213. <https://doi.org/10.1016/j.rser.2024.115213>.